Micro Evidence on the Environmental Kuznets Curve

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Abstract

Little micro research has quantified the relationship between income and pollution. Using a new California micro dataset on vehicle emissions, I estimate that a $1000 increase in individual income decreases emissions by .9%. These findings are relevant for predicting the time path of aggregate emissions and for improving used car vehicle emissions testing program's effectiveness.

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I. Introduction

Recent research has found evidence of a "U" shaped relation between national environmental quality and national income measures. Grossman and Krueger (1994) and Selden and Song (1994) present cross-national evidence that as nations grow richer they first degrade their environment. As income increases further, air quality increases. They estimate that the turning point for particulates and sulfur dioxide occurs at roughly $6000-$8000 dollars of GNP per-capita.[2] Their findings are based on "macro" regressions that fit a nation's air quality as a function of GNP per-capita. This research has not explored how the distribution of income affects environmental quality.

This macro research has not explored the micro underpinnings of this reduced form "U" shaped relation between environmental quality and income. At the individual level, little is known about how the supply of air pollution varies with income. This paper uses a new microdata set to explore how vehicle emissions co-move with owner income. Since vehicles are an important component in a geographical area's ozone and carbon monoxide levels, the vehicle emissions/income profile provides information about how aggregate air quality co-moves with vehicle owner income.

This paper uses a new California micro dataset to quantify the vehicle emissions and income relationship. If emissions Engel curves are not linear, then the distribution of income within a given geographical area matters when determining how aggregate emissions will vary with respect to income. Produce iso-emissions profiles for quantifying how emissions vary by income groups.

[2]Using United States state level particulate panel data in the 1980s, I have studied how particulate levels have evolved over time as a function of economic activity and have found no evidence of a "U" shaped pollution/income relation (Kahn 1994b).

White (1982) and Kahn (1994) have studied how vehicle emissions vary with model year. Cars built in the 1970s emit significantly higher levels of carbon monoxide and hydrocarbons than cars built in the 1980s and 1990s. Per mile of driving, it is likely that emissions is decreasing with respect to income. Poorer people drive older higher polluting cars and do not maintain them as well. Richer people buy newer cars and maintain them better but are likely to drive them more.

This paper is organized as follows. Section Two presents the data sources. Section Three sketches the empirical framework. Section Four discusses my findings and Section Five concludes.

II. Data

Empirical research on the relationship between household income and pollution externalities has suffered from a paucity of data. Vehicle emissions testing has created rich databases on vehicle emissions and their characteristics (Kahn 1994). Unfortunately, such databases have not collected extensive information about the driver. To estimate the vehicle emissions and income relation, I use California vehicle micro data. Starting in 1990, California began creating large micro datasets of cars' emissions and characteristics. This data exists because states whose counties had air pollution levels that exceeded the ozone or carbon monoxide air quality standards in 1982 were required under the Clean Air Act of 1977 to start vehicle emissions testing programs. In California, the program requires that all registered cars in counties that have the programs must have their emissions tested every two years.

The California Department of Consumer Affairs Bureau of Automotive Repairs has created the Random Roadside Tests. Each year vehicles are randomly selected to participate in an emissions test. Such vehicle owners did not anticipate that they would be sampled. Thus, this data provides insights into vehicle in use emissions. The 1993 Random Roadside data includes emissions indicators and vehicle characteristics but little information about the driver. For each vehicle, I have a measure of its emissions of hydrocarbons, carbon monoxide, while travelling at a speed of 2500 rpm. This measure is proportional to its emissions per gallon but the state EPA does not translate this reading into a measure of emissions per gallon.

This data is special because for each driver, I know his/her zip code. Zip codes are small enough geographical areas that zip code means are informative about the underlying population. For the 1990 Census, the Bureau of Census has created a zip code level file that includes the variable median family income. By merging this data to the 1993 Random Roadside data, I have a dataset that includes vehicle emissions, vehicle characteristics, and owner income. For any given household in a zip code, mean income is measured with error. Under the assumption, that the variance of household income within zip code is small relative to the variance across zip codes, this variable can be used to obtain a lower bound estimate of income's effect on vehicle emissions. The hydrocarbon data includes 1,276 observations and the carbon monoxide data includes 1,042 observations. There are 471 different zip codes represented in my data.

III. Vehicle Emissions as a Function of Income

Assume that the log of vehicle i's emissions can be expressed as a linear function of its model year, mileage, engine type, and owner income. Equation (1) presents the regression equation that includes dummy variables for each model year and engine cylinder specification;

$$\log(E_i) = B X_i + d I_i + U_i \quad (1)$$

Controlling for vehicle characteristics, I would predict that richer owners' cars pollute less at any point in time. Unfortunately, individual income is not observed. As a proxy for individual i's income, I use the median household income for those families that live in the same zip code as person i. Given that this is a noisy proxy for individual income, the results I report underestimate income's impact on emissions.

IV. Findings

Table One presents the summary statistics for the sample. Table Two presents estimates of equation (1) for hydrocarbons and carbon monoxide. These regressions fit a vehicle's emissions as a function of its model year, mileage, engine, and its owner's income. The mileage variable attempts to control for vehicle depreciation. The model year patterns indicate that both hydrocarbon and carbon monoxide emissions fell sharply in model year 1974. Carbon monoxide emissions fell sharply again in model year 1975 and with the exception of the 1980 model year were roughly constant until 1982 when carbon monoxide emissions fell sharply again. From 1981 until 1993, emissions have declined steadily. Hydrocarbon emissions fell sharply in 1974 an 1982 and 1986.

The key finding reported in this table is that controlling for all other factors a $1,000 increase in income reduces both hydrocarbons and carbon monoxide by .9%. This estimate is a lower bound of the income effect because the income proxy is measured with error.

I have also regressed vehicle model year on income and found that an extra $1,000 of income lowers the age of the car one owns by .055 years. If a person has an income of $40,000 and another person has an income of $24,000, then I predict that the former owns a car that is one year younger than the older. This is relevant for this study because Table Two indicates that the emissions profile is downward sloping with respect to model year. Thus, richer people pollute less both because of increased maintenance for any given car and they own newer vehicles. Such vehicles are also likely to have better fuel economy than older vehicles. For example, the average 1981 car built by GM achieved 23.8 MPG while the average 1991 car built by GM achieved 27.1 MPG. This is important because if a person drives 10,000 miles a year in a car that achieves 27.1 MPG he will use the same amount of gasoline as a person who drives 8,782 miles a year in a car that achieves 23.8 MPG. If fuel economy deteriorates with age, then new cars consume relatively less gas.

Richer people may drive more fuel efficient newer cars and they may drive more. Both factors are relevant in determining how an individual car owner's aggregate yearly emissions vary by income level. For any given level of income I, total yearly vehicle emissions are expressed in equation (2).[3]

$$E(I) = e(I) * k * (mpg(I))^{-1} * miles(I) \tag{2}$$

In equation (2), e represents emissions as indicated in my data, mpg represents vehicle miles per gallon and miles is vehicle mileage. Taking a ratio of emissions of a car whose owner's income is I versus another vehicle whose income is "base" yields;

[3] k represents the unknown factor mapping my emissions reading into emissions per mile.

$$E(I) / E(base) = (e(I) / e(base))*(mpg(base) / mpg(I))*(miles(I) / miles(base)) \quad (3)$$

Suppose the two groups have the same emissions, then the left hand side of equation (3) equls one. Solving for the mileage ratio such that the emissions are equal across the two income groups yields equation (4).

$$miles(I) / miles(base) = (e(base)*mpg(I)) / (e(I))*(mpg(base)) \quad (4)$$

Equation (4) represents the mileage ratio of different income groups such that their total emissions are equal. I call this the iso-emissions curve. Table Three presents my estimates of the iso-emissions surface portrayed in equation (4). I use predicted hydrocarbons and carbon monoxide by income group as my proxy for E(I) and the base income category is $10,000-19,000. Data from the AAMA Motor Vehicles Facts & Figures 1993 is used to determine average vehicle fuel economy. I use General Motors's average fleet fuel economy in each model year by taking the estimated equation; model year = 82.6 + .055*income and predicting model year for each income group. This model year was then matched to the General Motors average fuel economy.[4]

Table Three's right two columns present the mileage ratio of a given income group relative to the first income group such that total yearly emissions of the two groups would be equal. For example, Table Three indicates that owners with income of $75,000 would have to drive 3.67 times

[4]The fuel economy estimates (measured in miles per gallon) are: $10-19 is 24, $20-29 is 24, $30-39 is 25.8, $40-49 is 25.8, $50-59 is 25.8, $60-69 is 25.8, $70-79 is 26.9, $80-89 is 26.9, $90-99 is 27.6, $100-109 is 27.3, and $110-119 is 27.3.

as much as owners with income of $15,000 for them to produce the same level of hydrocarbon pollution. If the former were to drive only twice as much, then they would pollute less than the base group. If the former group drove four times as much, then my estimates predict that in aggregate they would pollute more. The estimates suggest that it is quite likely that people with incomes over $75,000 do pollute less than poorer people. These estimates provide some insights into how large the mileage income elasticity would have to be for richer people to actually pollute more. Interestingly, in a recent study using microdata from the consumer expenditure survey, Goldberg (1994) finds no evidence of a statistically large income elasticity for mileage.

V. Conclusion

This paper has used a new microdata set to explore this relationship for California vehicle owners. My findings suggest that richer people do pollute less unless they drive a very large number of miles. Thse findings have implications for how state regulators target environmental regulation. Polluters have private information about their vehicle's emissions. Regulators must choose a probability of monitoring each driver and a repair and fine schedule conditional on failing the test. Current emissions testing regulation has not imposed stringent penalities and little evidence suggests that it has been effective (Lawson 1993). If richer people were creating a majority of the emissions, it is likely that a regulator would be willing to target increased regulatory effort at the wealthy. Conversely, taking equity considerations into account, existing regulation has not forced owners of highly polluting older cars to expend great effort to reduce vehicle emissions probably because it is thought that such regulation would be a regressive tax. If such groups could be targeted, then it is possible that universal emissions testing would not be needed in locations that are not achieving Clean Air Standards.

References

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Table One

Summary Statistics

Variable	obs	mean	s.d
model year	1324	84.8	5.4
cylinders	1324	5.4	1.6
income	1324	38.7	13.8
hydrocarbons	1324	71.8	243
carbon monoxide	1324	.62	1.54
mileage	1324	75.3	69.2

Table Two

California Car Emissions and Income in 1993

	hydrocarbons		carbon monoxide	
	coefficient	t-statistic	coefficient	t-statistic
income	-.009	-3.3	-.009	-2.15
1969 model year	-.27	-.49	.16	.24
1970 model year	.43	.72	-.77	-1.04
1971 model year	.65	1.06	.44	.58
1972 model year	1.56	2.5	-.29	-.38
1973 model year	-.27	-.46	.20	.28
1974 model year	-.93	-1.72	-.95	-1.42
1975 model year	-1.49	-2.98	-1.41	-2.28
1976 model year	-1.06	-2.25	-1.48	-2.54
1977 model year	-1.02	-2.16	-1.96	-3.34
1978 model year	-1.62	-3.66	-2.07	-3.73
1979 model year	-.87	-2.03	-1.52	-2.85
1980 model year	-1.10	-2.44	-.78	-1.36
1981 model year	-1.07	-2.45	-1.43	-2.60
1982 model year	-1.47	-3.48	-1.77	-3.31
1983 model year	-1.31	-3.08	-2.38	-4.49
1984 model year	-1.34	-3.26	-2.13	-4.13
1985 model year	-1.58	-3.87	-2.58	-5.05
1986 model year	-2.01	-4.97	-2.75	-5.36
1987 model year	-2.01	-4.95	-2.76	-5.36
1988 model year	-2.46	-6.02	-3.55	-6.84
1989 model year	-2.82	-6.96	-3.68	-7.10
1990 model year	-2.84	-7.00	-3.83	-7.29
1991 model year	-2.94	-7.15	-3.73	-7.07
1992 model year	-3.31	-7.49	-4.28	-7.43
1993 model year	-2.83	-2.00	-4.36	-8.37
6 cylinders	-.18	-1.96	-.52	-3.79
8 cylinders	-.22	-1.88	-.74	-5.00
car dummy	-.18	-1.96	-.47	-3.66
mileage	.0019	3.20	.0022	2.94
constant	4.99	12.1	1.22	2.34
obs / R squared	1261 .31		1031 .30	

Note: The dependent variable is the log of a car's emissions. Independent variables include; model year dummies, 1968 is the omitted category, engine cylinder dummies, 4 cylinders is the omitted category, mileage measured in 10,000 miles and a dummy indicating whether the vehicle is a car. Income is measured in $1000s

Table Three

Predicted Pollution by Income Category

income (measured in thousands)	predicted hydrocarbons	predicted carbon monoxide	predicted mileage ratio for iso-hc curve	predicted mileage ratio for iso-co curve
10-19	25.2	.35	1	1
20-29	20.8	.29	1.21	1.21
30-39	17.2	.23	1.58	1.64
40-49	14.1	.19	1.92	1.98
50-59	11.6	.15	2.34	2.51
60-69	9.5	.12	2.85	3.14
70-79	7.7	.10	3.67	3.92
80-89	6.3	.08	4.48	4.90
90-99	5.1	.06	5.68	6.71
100-109	4.1	.05	7.07	8.05
110-119	3.3	.04	8.69	9.95

The iso-emissions ratios are formed from equation (4). I solve for that quantity of mileage such that total emissions for that income group would equal to the average emissions f people with income $10,000-$19,000.